e-Tendering readiness in construction: the posterior model

Al Yahya, Moath; Skitmore, Martin; Bridge, Adrian; Nepal, Madhav; Cattell, David

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e-TENDERING READINESS IN CONSTRUCTION: POSTERIOR MODEL

ABSTRACT

Purpose

To verified a conceptual model for e-Tendering readiness in any construction organisation prior to implementation.

Design/methodology/approach

Based on the conceptual model called e-Tendering readiness model (e-TRM), this paper empirically examines the e-TRM's interactions and causal relationships between e-Tendering constructs and e-Tendering readiness. Structural equation modelling is used to test the hypothesised positive inter-relationships. A questionnaire survey is conducted of construction organisations in Saudi Arabia to understand their current e-Tendering readiness and importance of e-Tendering variables.

Findings

Supported by empirical evidence, the paper recognises that three out of nine constructs have a direct influence on e-Tendering readiness. One of the constructs is hypothesised for the first time and turns out to have the most effect when tested.

Research limitations/implications

The empirical test for the e-TRM is restricted to Saudi Arabia which, though not atypical of most countries' e-tendering around the world, needs to be further tested in other areas for additional verification.

Practical implications

To update previous IT/IS models in construction by adding this tested model to the research literature on traditional and electronic tendering and the body of knowledge in the construction industry.

Originality/value

The Service Providers construct is proposed and tested for the first time, which is necessary to support the successful e-Tendering implementation.

Keywords

e-Tendering, e-Procurement

Paper type

Conceptual paper

1. INTRODUCTION

E-Procurement involves a set of technologies such as e-Tendering, e-Auctions, e-Catalogue/Purchasing, e-Marketplace and e-Invoicing (Soar et al., 2004); the literature relating to e-Procurement often uses the term e-Tendering as a default, which is defined by Betts (2006) as the procurement process simply conducted online.

e-Tendering benefits

E-Tendering can enhance tendering practice in many ways. For example, both the construction industry and government organisations agree that the traditional tendering process takes too much money and time, and the process would be much cheaper and faster if e-Tendering was used instead (Kajewski and Weippert, 2004). Cost and time would be saved and productivity would increase, along with an enhanced competitiveness and improvement in an organisation's market share opportunities (Lenin, 2011).

Moreover, Trkman and McCormack (2010) posit that one of the main benefits of e-Procurement is an increase in the competitiveness, both financial and technical, of the tenderer's proposal. Additionally, contractors have benefited from the reduction in tender papers; hence, they are willing to profit from the significant time and cost savings in their e-Tendering work (McAllister and McClave, 2010).

Lavelle and Bardon (2009) identify five main benefits that can be gained from e-Tendering: less administration costs for paperwork; improved two-way communications between the parties (contractors and sub-contractors); faster response to enquiries; a lesser timeframe for the tendering life cycle; and help in analysing the tenders. Farzin and Nezhad (2010) also identify the benefits of e-Procurement in three main areas of construction: strategies, opportunities and operations. Research by Zhang and Yang (2011) also highlights a number of other benefits from using e-Tendering that can minimise collusion or make it more difficult for it to take place.

Also, establishing or improving the use of e-Tendering promises to allow construction organisations to update to best practice by exploiting the potentials of technology. As the move to e-Tendering use becomes a globe norm, even though there is a slow uptake in construction, e-Tendering users are benefiting from the savings in time and money, improvements in quality and performance, and increases in their competitive advantage. Tenderers who use traditional tendering miss opportunities through not keeping pace with new technology.

What are e-Readiness and maturity models?

The failure or success of any electronic system can only be judged by a suitable assessment measure (Eriksson and Westerberg, 2011). Eadie et al. (2012) investigate the structure behind the different models, including e-Readiness models and maturity models. They find that the e-Readiness model is used for pre-adoption assessment, while the maturity model is for post-adoption assessment; they identify 8 e-Readiness models and 53 maturity models. It is clear, therefore, that less attention is being paid to pre-adoption models. This indicates the need for a greater research focus on the pre-adoption of e-Procurement and e-Tendering. Moreover, Eriksson and Westerberg (2011) find that earlier research in e-Procurement focuses on the three success criteria of cost, time and quality, which are all post-adoption. Many e-Procurement studies also focus on post-adoption in terms of implementation, improvements in efficiency, and the process and the announcement of the tender (Croom and Brandon-Jones, 2007).

Organisations need to assess their e-Tendering readiness in order to implement e-Tendering successfully. Importantly, Chanyagorn and Kungwannarongkun (2011) highlight the benefits of having an IT/IS readiness assessment model:

- It is an evaluation tool used to measure the current state of organisations' ICT utilisation and ICT penetration levels.
- The results from using the model indicate the capability to successfully adopt, utilise and benefit from the ICT of assessed organisations.
- The model provides frameworks and critical indicators that are derived from macro perspective models.

There is a high chance of successfully implementing e-Tendering by using such a readiness measurement tool. As Gudergan et al. (2015) assert, "a company's specific change readiness has a significant influence on the success of the transformation towards a solution [based] business."

Why has construction been slow to adopt e-Tendering?

In the last decade, the use of e-Procurement has increased in construction procurement technologies; however, the construction sector has been slower to adopt it than the manufacturing and retailing sectors (Laryea and Ibem, 2014). This may be because the organisation is not ready to shift to electronic practices, or is not focused on post-adoption.

In the other hand, e-Procurement in the construction industry is more complicated than in other industries such as goods and services. The reasons for this becomes clearer when comparing the adoption of e-Procurement barriers and challenges in construction to the barriers in other industries (Eadie et al., 2011). The late implementation of IT/IS in the construction process is due to the construction industry itself having unique characteristics in terms of its product, complexity, size and the location of projects (Aziz and Salleh, 2011).

There are two possible reasons why the adoption of e-Tendering has been limited in the construction industry. Firstly**,** research into construction e-Tendering is not consistent, but varies according to whether it focuses on factors such as people, processes, work environments or technology. Moreover, as Eadie et al. (2012) reveal in their review, IT/IS research in general focuses on post-adoption. In support, Wendler (2012) states that "most publications deal with the development of maturity models and empirical studies." Wendler (2012) has conducted a systematic review of maturity models in Information Systems (IS), reflecting their development in each area of research. As an indicator, there were 89 software development/engineering models by 2012, due to the dissemination and success of maturity models emerging from the software industry. On the other hand, there were 17 project management models, 10 construction process/engineering models and 10 process management models, demonstrating the impact of continuous research in the software development/engineering field. However, the construction industry is still failing to achieve comparable rates of IT use (Aziz and Salleh, 2011).

The second issue is the lack of an effective and specialised model or framework to assess the readiness for use of construction organisations' e-Tendering processes. As Aziz and Salleh (2011) observe, "a commonly cited problem that exists with e-Readiness is the fact that there are many different types of measures available today and that there is no standardization of these measures."

None of these models and frameworks is suitable for assessing the readiness of a construction organisation to adopt e-Tendering since they do not cover the full range of construction tendering activities, are outdated and not designed for general e-Procurement purposes. Moreover, the other available e-Readiness models are also not suitable for construction use as they vary in their economic and social use, which makes them difficult to apply to construction procurement (Aziz and Salleh, 2011).

2. THE NEED FOR A CONSTRUCTION E-TENDERING READINESS MODEL

There is a growing interest in e-Tendering and its models and frameworks (technical or functional), which tend to vary according to the different aspects of e-Tendering. However, the lack of clear guidelines has led to confusion, especially among those seeking to use e-Tendering. The e-Tendering guidelines for organisations cover the requirements for successful implementation. Vaidya et al. (2006) identify the five stages of implementation as initiation, adoption, acceptance, routinisation and infusion. All these stages cover organisational aspects: people, process, work environment, technology and service providers. This raises the question of what exactly needs to be done to implement e-Tendering successfully. Therefore, there is a need for a structured framework to guide organisations towards e-Tendering implementation. Zunk et al. (2014) reveal that e-Tendering in construction has a low implementation rate compared to other industries. According to Tran et al. (2011), the main themes and factors that are viewed as challenges and obstacles when an organisation is implementing e-procurement in construction are technology, management, organisation and the environment.

The e-Tendering processes used in construction projects are not smart enough to complete the full cycle of the e-Tendering process (Lenin, 2011). While there is no specific e-Tendering readiness measure, it is hard to develop any Key Performance Indicator (KPI) without benchmarks for the organisation's readiness for e-Tendering. So, prior to implementing e-Procurement in general or e-Tendering in particular, Chen and Rankin (2006) advise on setting benchmarks for the organisation. In general, the e-Readiness model makes an assessment at a particular moment of time with positive or negative results (Eadie et al., 2012). However, as Lou and Goulding (2010) observe, in the construction sector, "e-Readiness at the organisational level is still in its infancy." Finally, the organisation must reach a required level of readiness to successfully integrate innovation into its work practices prior to investment (Lou, 2010).

Nowadays, organisations that consider partially or fully shifting to the digital world need to measure themselves prior to this change (Rafferty et al., 2013). As Goulding and Lou (2013) comment, "the term e-Readiness is coined to measure the degree to which an organisation may be ready, prepared, or willing to obtain benefits, which arises from the digital economy". Therefore, Lou and Alshawi (2009), in their study of CSFs in the implementation of e-Tendering suggest further research into whether "organisations could adopt a 'measured approach' to help them be 'e-ready'." Finally, a measured approach helps organisations to increase their capability and results in a practical framework to ensure their e-Readiness prior to implementation.

3. THE A PRIORI E-TRM

This paper examines a developed model by Alyahya et al. (in press) that has been developed in relation to construction practice, including e-Readiness, e-Procurement and e-Tendering. The e-TRM's items are first coded and then grouped and allocated to their suitable constructs. Each construct is then allocated to a specific theme based on its meaning. This involves five potential themes with thirteen constructs. The themes comprise the following constructs: people [skill and staff]; process [practice and procurers]; technology [system and software and networking]; work environment [leadership, management, culture and structure]; and service provider [communication, market and technical]. The following sub-sections highlight the development and features of a Priori e-TRM.

Developing a Specific Model

The development of e-TRM is conducted through a series of modelling development steps. It starts by reviewing some deficiencies in e-Tendering readiness in the construction sector. One of the main shortcomings is the lack of a specific model to measure the readiness of construction organisations to adopt e-Tendering (Lou and Alshawi, 2009). Eadie et al. (2012) find that the available ICT models for construction are hard to apply for various reasons. For instance, theoretical models not specifically for e-Tendering may lack important constructs, may cover e-Tendering only partially or may be specific for certain countries. In addition, some previous studies focus more on e-Tendering tools or concepts such as process, people, systems, implementation, solution, cases studies, barriers, drivers or critical success factors (CSFs). Moreover, it is hard to apply any general model to estimate the readiness of e-Tendering for construction usage (Aziz and Salleh, 2011).

Furthermore, organisations tend to focus on technology, which is no longer a barrier; human resources is the main factor influencing the successful implementation of e-Tendering, in terms of employee motivation, interest in IT, and attitude and prior experience within collaborative environments (Lou and Alshawi, 2009). It is important to combine both academic and industrial practices for an organisation to be able to embrace IT/IS successfully; failure to do this has resulted in many investments in IT/IS failing to meet their intended business objectives over the past decade (Goulding and Lou, 2013).

As e-Readiness comes first in the preparatory stage for any e-system, it is essential to focus at the beginning rather than jump to the later stages. As such, the primary objective of the e-TRM is to assess e-Tendering readiness for construction organisations and testing a specific model is the key. The main aim of this paper is to verify the conceptual model to assess a construction organisation's readiness for implementing e-Tendering.

A Priori e-TRM Structure

The following summarise the applied changes in e-TRM based on previous general models:

- **People theme:** The IT/IS construct is divided into people and technology theme constructs. The reset constructs are still the same as Saleh and Alshawi (2005), which are skills and staff.
- **Process theme:** the practice construct is kept as Saleh and Alshawi (2005) proposed, while the business process construct is replaced with a procedures construct.
- **Technology theme:** the IT/IS infrastructure theme is renamed as technology. Also, the system and communication construct is replaced with system and software. A networking construct is added.
- **Work environment theme:** The management culture and structure constructs are added to the theme, and IT department and organisational behaviour are withdrawn. The work environment theme constructs become much closer to the initial model of Saleh and Alshawi (2005).
- **Service provider theme:** A fifth theme, which includes contractors, subcontractors, suppliers, the engineering office and project management, is proposed. Additionally, communication, market and technical constructs are added to the service provider theme.

Features of A Priori e-TRM

Based on the Figure.1, Alyahya et al. (in press) suggest some conditions that need to identified and incorporated into the new theoretical model. The e-TRM features are; a) to be used before e-Tendering implementation; b) to provide a certain status for an organisation with regard to its e-Tendering readiness; c) is specific for e-Tendering readiness in the construction sector; and d) e-TRM is holistic in coverage and specific in assessment. That means it focuses on issues related to e-Tendering, which embrace all the key organisational themes such as people, process, technology, work environment and service providers, throughout the departments and stakeholders.

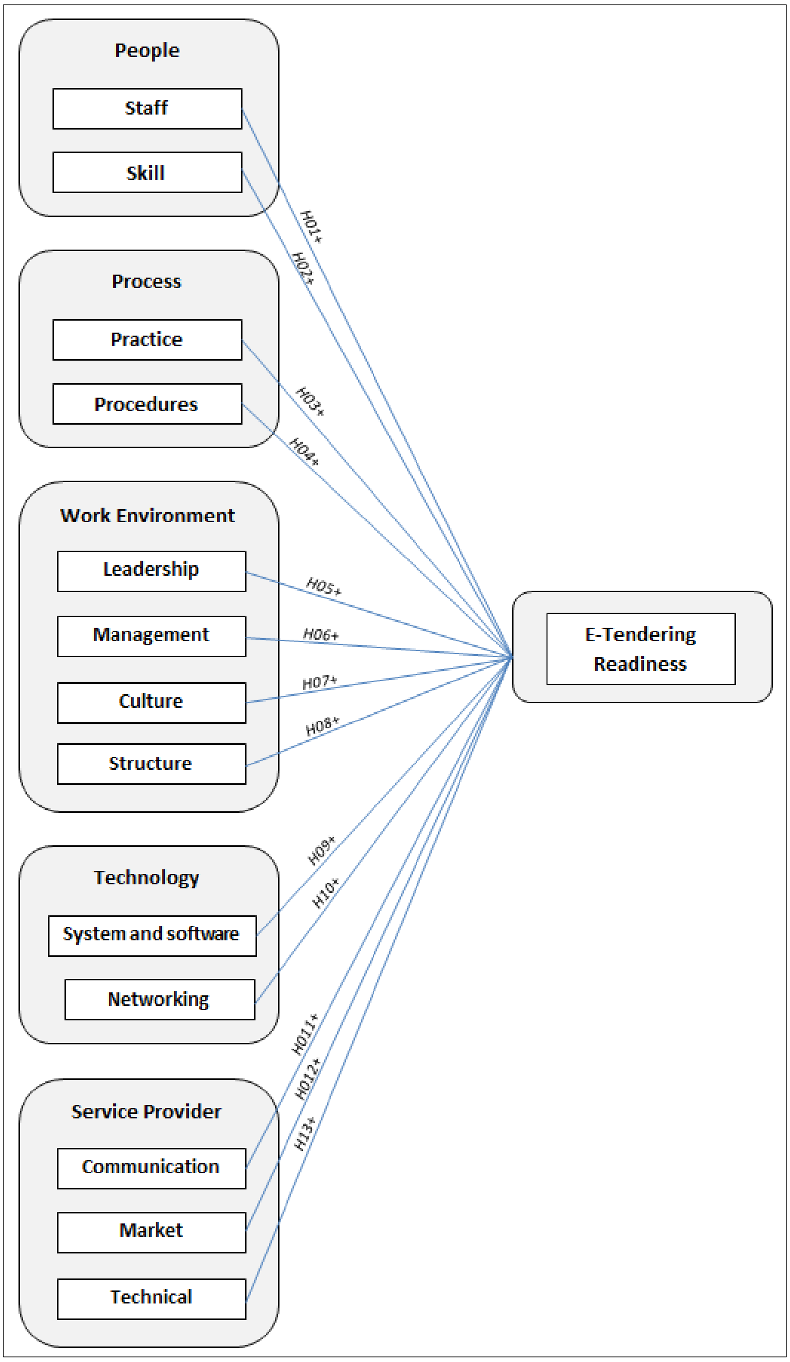

Figure.1 A Priori model (Alyahya et al., in press)

4. METHODOLOGY

To achieve this paper's objective, the a priori e-TRM hypothesised previously is to be empirically tested. To examine the a priori e-TRM, a customised e-Tendering readiness scale (e-TRS) is developed. Then, information is used that is gathered from 192 qualified respondents with experience in construction procurement. The first part of the questionnaire is devoted to demographic information about the respondents., to understand the respondents' organisation roles, types and to ensure the respondents have an appropriate experience. Consequently, this part of the questionnaire is useful in identifying any discrepancies in the responses received. Only the results pertaining to respondents who have experience in construction procurement are reported. The questionnaire survey covers the e-Tendering items and their latent construct, comprising six themes representing e-Tendering readiness. All the items are rated on a five-point Likert-scale ranging from 1 (not important) and 5 (very important).

Once the dataset is edited and initial tests are completed, the semantic differential data are subjected to principal component analyses (PCA). The PCA is used for checking the validity of the constructs and the internal consistency of the variables. The main purpose of conducting PCA in this study is to examine the existence of the factors (constructs) of e-Tendering in construction and reduce the items in the set of variables.

The statistical technique of confirmatory factor analysis (CFA) is conducted to check the appropriateness of the factorised grouping of variables (items). This is followed by structural equation modelling (SEM) to gain insights into the relationships between e-TRM constructs. A path analysis is conducted that uses observed variables only and establishes a causal flow.

5. FACTOR ANALYSIS

The factor analysis (FA) method is used in the early stages of data analysis to gather information about interrelationships among a set of variables and to reduce the number of items (Osborne and Costello, 2009). FA has many uses; Williams et al. (2012) indicate the main three uses which fulfil this study's needs: "Firstly, factor analysis reduces a large number of variables into a smaller set of variables. Secondly, it establishes the underlying dimensions between measured variables and latent constructs, thereby allowing the formation and refinement of theory. Thirdly, it provides construct validity evidence of self-reporting scales". The strong data in factor analysis means there are uniformly high communalities without cross loadings, and several variables load strongly on each factor (Osborne, 2009).

The aim of this paper is to examine the e-TRM that been developed conceptually by (Alyahya et al., in press). Therefore, there is no need to use EFA, as the number of constructs is determined before the analysis. On the other hand, confirmatory factor analysis (CFA) as Rencher and Christensen (2012) state, "allows the researcher to hypothesize the number of [constructs] and the specific nature of the latent structure in the data, and then test the hypotheses that have been formulated". Consequently, the CFA using SEM is used as suggested by Rencher and Christensen (2012) to formulate the model, estimate the parameters, evaluate the model and make statistical inferences after the PCA.

Principal Component

Once the editing and initial tests are completed, the semantic differential data are subjected to PCA. According to (Osborne and Costello, 2009), PCA is a common method used for checking the validity of the constructs and the internal consistency among the variables in a set of data. DeCoster (1998) states that PCA should be used when the aim of the analysis is to perform data reduction. PCA can be used to solve three major problems: (a) removing superfluous/unrelated variables; (b) reducing redundancy in a set of variables; and (c) removing multicollinearity (Laerd, 2015). The main purpose of conducting PCA in this study is to examine the existence of the factors (constructs) of e-Tendering in construction and reduce the items in the set of variables.

For the sample size (number of cases), Tabachnick and Fidell (2007) explain that it is appropriate to have at least 300 cases for factor analysis, but 150 cases is sufficient if the solutions have several high loading marker variables (above 0.80). In this paper, a total of 192 cases are qualified to be considered for the analysis.

The Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) test for strength of the inter-correlations among the items are used to assess the factorability of the data, as Pallant (2013) suggests. Tabachnick and Fidell (2007) recommend that Bartlett's test of sphericity should be significant ($p < 0.05$) for factor analysis to be considered appropriate, while a KMO index of 0.6 is suggested as the minimum value for a good factor analysis.

Results of the PCA

The PCA is conducted for all the 92 items that represent the individual factors as one group and shows that the Bartlett test of sphericity is significant, with the overall Kaiser–Meyer–Olkin (KMO) measure of the sampling adequacy index at 0.842. The Varimax is used with Kaiser Normalisation as the rotation method, which convergences in eight iterations. Table.1 presents the detailed results of the PCA based on an eigenvalue greater than one (> 1.0),. There are 51 remaining items, which are extracted into nine factors that account for 60.32% of the total variance.

All the items have a significant loading, and the average variance extracted for each factor is exceeded. Once the nine factors are identified, the Cronbach's alpha test is applied to ensure the appropriateness of the groupings of the factors extracted. As shown in Table.1, the alpha coefficients range from 0.918 to 0.711, all of which are considered to be within the 'excellent' to 'acceptable/reliable' range, except the system and software factor, which has a questionable Cronbach alpha range with a result of 0.653. The rules of thumb for Cronbach's alpha are to be followed Gliem and Gliem (2003), George and Mallery (2003): > .9 – Excellent, _ > .8 – Good, _ > .7 – Acceptable, _ > .6 – Questionable, _ > .5 – Poor, and _ < .5 – Unacceptable.

So, at this stage, the constructs (factor) and their item loadings will be assessed again during SEM.

Table.1 PCA results

Construct	Cronbach's Alpha	Item code	Item code	Loading
Service Provider	.913	Data sharing with subcontractor or supplier partners	Part2_E_13	.758
		Involvement of design office	Part2_E_3	.726
		Technical infrastructure within the construction industry	Part2_E_15	.708
		Demand from tenderer	Part2_E_6	.699
		Regulatory framework within public procurement	Part2_E_10	.677
		A "wait-and-see" attitude among companies	Part2_E_5	.662
		Pressure from competitors	Part2_E_7	.641
		Poor industry standards for information interchange	Part2_E_16	.628
		Training services for e-Tendering system from tenderee to tenderer	Part2_E_17	.628
		Tenderer, tenderee, subcontractors and suppliers have symmetry of technical readiness	Part2_E_11	.596
		Reduced local companies (national or international companies became targeted)	Part2_E_9	.576
		Tenderer and supplier have BIM experience	Part2_E_12	.552
		Include training procedures for e-Tendering system in contract	Part2_E_18	.546
		Shared technical platform between tender parties to exchange document	Part2_E_19	.542
Leadership	.861	Clear vision and objectives	Part2_C_5	.783
		Effective leadership	Part2_C_1	.747
		Top or strategic management commitment for e-Tendering	Part2_C_2	.670
		Forum to exchange ideas	Part2_C_4	.648
		Flexibility of organisation's law and system	Part2_C_3	.629
		Company policy	Part2_C_7	.611
		Widely accepted e-Tendering system solution	Part2_C_6	.601
		Development of confidence to use new technologies	Part2_A_6	.567
		Electronic bid evaluation	Part2_B_21	.530
Structure	.730	Complex hierarchical structure of organisation	Part2_C_27	.742
		Organisation's hierarchical structure doesn't support IT implementation	Part2_C_28	.709

		One-off project feature (organisation has only one project)	Part2_B_12	.615
		Difficulty of implementing e-Tendering system	Part2_D_11	.552
		Not top priority of the company	Part2_C_8	.538
		Staff resistance to change (prefer to stay with the current system)	Part2_A_5	.537
Practice	.907	Clarity of tenderee information legal	Part2_B_7	.838
		Clarity of tenderer information legal	Part2_B_6	.823
		Clarity of supplier information legal	Part2_B_8	.796
Networking	.815	Poor IT infrastructure	Part2_D_15	.779
		Company access to internet	Part2_D_13	.692
		Do not have IT infrastructure for e-Tendering (software, hardware, support and network)	Part2_D_16	.662
		Security concerns	Part2_D_14	.567
Management	830	e-Tendering implementation cost	Part2_C_19	.854
		e-Tendering systems cost (includes system licences)	Part2_C_18	.795
		Insufficient financial support	Part2_C_20	.700
		Cost of IT investment (all costs)	Part2_C_17	.660
Procedure	.782	Unauthorised viewing	Part2_B_18	.743
		Data transmission to the wrong person	Part2_B_17	.715
		Confidentiality of information	Part2_B_19	.709
		Prevention of tampering with documents	Part2_B_20	.629
System and Software	.709	External interoperability (integration) of e-Tendering system	Part2_D_1	.684
		IT systems (e-Tendering excluded) have been implemented in an ad hoc manner	Part2_D_2	.623
		Internal interoperability (integration) concerns	Part2_D_4	.619
		Investment in incompatible systems	Part2_D_3	.615
Regulation	.711	The legal position of e-Tendering	Part2_B_1	.749
		Pertinent case law	Part2_B_3	.647
		Different national approaches to e-Tendering legal	Part2_B_2	.642

Extended a priori e-TRM

The PCA outcomes contain nine constructs (latent factors) with a total of 51 items. Figure.2 shows the extended a priori e-TRM.

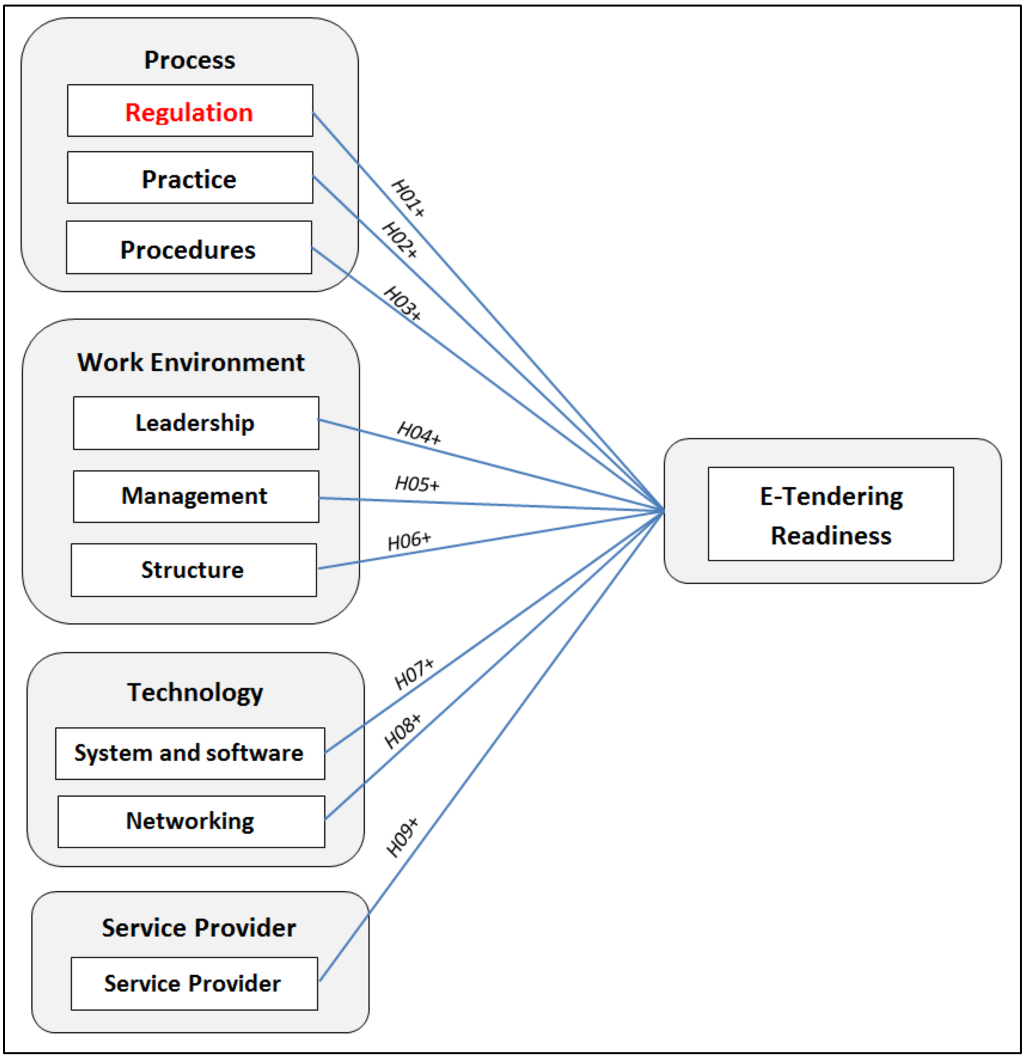

Figure.2 Extended a priori e-TRM

The conceptual e-TRM a priori contains 13 constructs with five themes. However, after the PCA is conducted, there are not many changes in terms of the constructs. The extended a priori e-TRM has a new construct called "regulation" which belongs to the theme "process". This updates the e-TRM hypotheses to assume the regulation has an effect on the e-Tendering readiness, which leads to the following readiness criterion:

H01: *The regulation in the theme of Process significantly influences the organisation's level of readiness to implement e-Tendering.*

Moreover, the hypothesis service provider theme with its three constructs turns into one construct with the highest Cronbach's Alpha (.913). Interestingly, this theme and its items are hypothesised for first time to have e-Tendering readiness. Therefore, the Service Providers' construct leads to the modified proposal of the hypothesis:

H09: *A construction organisation's level of readiness to implement e-Tendering is significantly affected by the organisation's service providers.*

Lastly, the changes to the conceptual a priori e-TRM can be summarised as three constructs belonging to the same theme, combined into one construct, and a new construct identified from the same theme. Once the factors are developed using PCA, CFA is applied to answer the research questions (Osborne and Costello, 2009).

6. STRUCTURAL EQUATION MODELLING (SEM)

According to Crockett (2012), “SEM is a second-generation multivariate analysis technique that is used to determine the extent to which an a priori theoretical model is supported by the sample data”. Generally, SEM has two model types; measurement and structural models. The concern is how well the observed variables measure the latent factors, addressing their reliability and validity (Molenaar et al., 2000). According to Gefen et al. (2000), SEM also helps with modelling the relationships between the latent factors, by describing the amount of explained and unexplained variance. Thus, the details of the measurement and structural models for this study are explained in the following sections.

Confirmatory factor analysis (CFA)

First of all, CFA is performed to validate the measurement model and to confirm whether the collected data are an appropriate fit with the hypothesised model before conducting further statistical analysis. This is conducted to examine whether the measurement items (variables) are loaded on the constructs (latent factors) in the expected direction. CFA specifies the theorised relations of the observed variables to their proposed constructs, and it allows for the assessment of fit between the observed data in the conceptualised a priori model and their hypothesised causal relationships with the latent factors (Mueller and Hancock, 2008).

Initially, the structural model is meaningless without a good measurement model. According to Byrne (2016) there are three ways to assess a measurement model; (a) the feasibility of the parameter estimates; (b) the appropriateness of the standard errors; and (c) the statistical significance of the parameter estimates. Each method is described in detail in the following subsections. In this study, the CFA is undertaken to establish confidence in the measurement model.

Assessment criteria for measurement model

The assessment of any SEM model needs to meet some basic requirements, known as the goodness of fit (GOF). These requirements give reliable indications about the collected data to fit the hypothesised model. Certain criteria for a good fit model are followed, for which Hair (2010) suggests the following criteria: minimum discrepancy (chi-square, χ^2) divided by the degree of freedom (df)<2.0 for an excellent fit; Root Mean Square Residual (RMR)<0.1; comparative fit index (CFI)>0.90; incremental fit index (IFI)>0.90; root mean square error of approximation (RMSEA)<0.08; and P-Value of Close Fit (PCLOSE)>0.05. Kline (2016) suggests some requirements to be followed for construct validity, which is the convergent validity of: factor loadings > .50 and discriminant validity; and correlation coefficients less than 0.85 for each pair of constructs.

Measurement model results

In Figure.3, the model is assessed for the ten constructs: service provider (SerPro), leadership (Led), practice (Pra), procedures (Pro), management (Mag), networking (Net), structure (Str), regulation (Reg) and system and software (SysSof) to e-Tendering readiness (eTR). Figure.3 presents the archived CFA model with no structural relationships among the constructs.

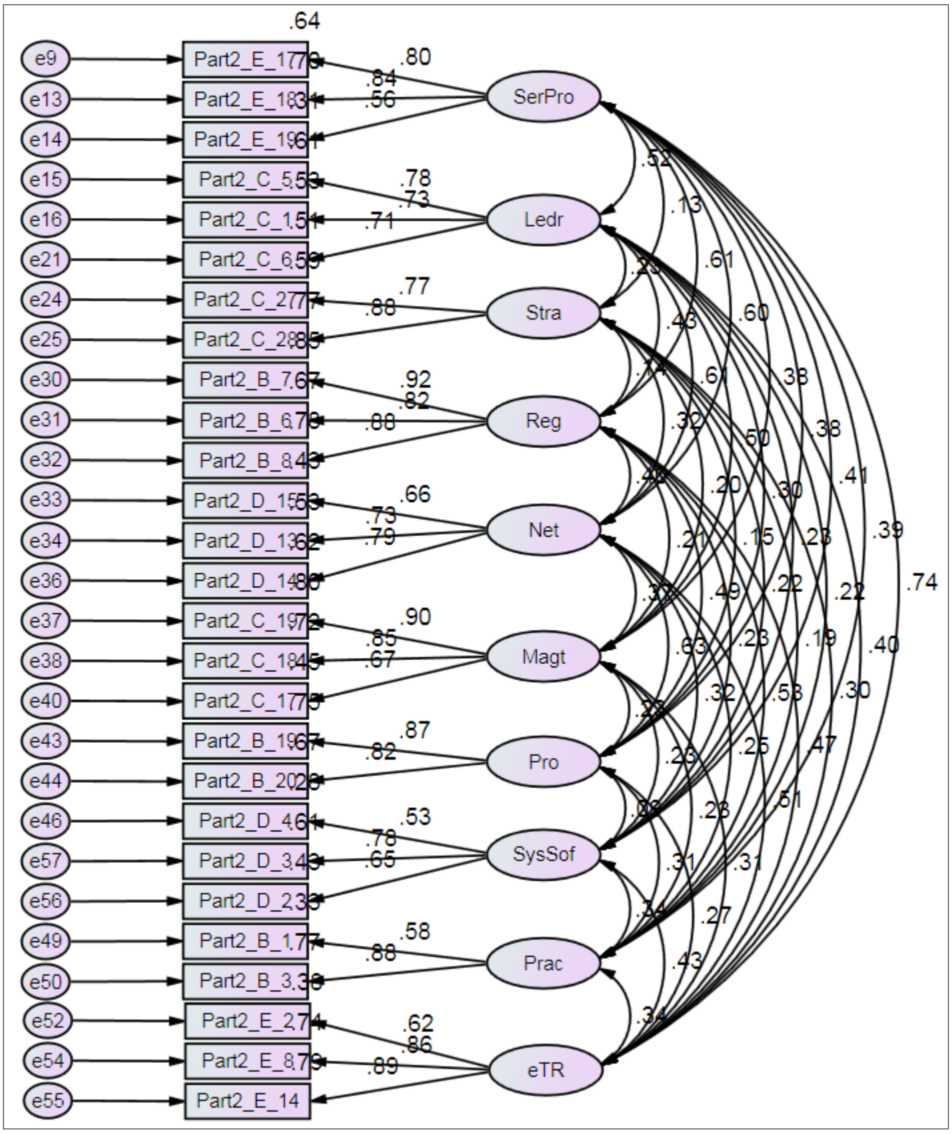

Figure.3 Measurement model

Table.2 Results of CFA for the Model

Construct	Items	Estimate Substandard	Standard Error	Critical Ratio	Standard Estimate Loading	P
Service Provider	Part2_E_17	1			0.80	
	Part2_E_18	1.007	0.086	11.709	0.84	***
	Part2_E_19	0.779	0.103	7.594	0.56	***
Leadership	Part2_C_5	1			0.78	
	Part2_C_1	0.917	0.102	9.011	0.73	***
	Part2_C_6	1.012	0.114	8.851	0.71	***
Structure	Part2_C_27	1			0.77	
	Part2_C_28	1.169	0.216	5.424	0.88	***
Regulation	Part2_B_7	1			0.92	
	Part2_B_6	0.923	0.06	15.423	0.82	***
	Part2_B_8	1.014	0.057	17.693	0.88	***
Networking	Part2_D_15	1			0.66	

	Part2_D_13	0.992	0.122	8.155	0.73	***
	Part2_D_14	1.03	0.12	8.562	0.79	***
Management	Part2_C_19	1			0.90	
	Part2_C_18	0.929	0.073	12.723	0.85	***
	Part2_C_17	0.641	0.065	9.903	0.67	***
Procedure	Part2_B_19	1			0.87	
	Part2_B_20	0.92	0.093	9.867	0.82	***
System and Software	Part2_D_4	1			0.53	
	Part2_D_2	1.651	0.289	5.703	0.65	***
	Part2_D_3	1.793	0.312	5.749	0.78	***
Practice	Part2_B_1	1			0.58	
	Part2_B_3	1.506	0.291	5.174	0.88	***
e-Tendering Readiness	Part2_E_2	1			0.62	
	Part2_E_8	1.346	0.149	9.024	0.86	***
	Part2_E_14	1.332	0.146	9.143	0.89	***

*** Means that P is significant at level less than 0.001

Model fit assessment

The model has a good fit with acceptable model fit indices. Table.3 presents these values, which give a reliable indication of the extent to which the collected data fit the hypothesised model (e-TRM) and proposed measurement (Hair Jr et al., 2010).

Table.3 Model fit results and criteria suggested by Hair (2010)

	CMIN/DF	RMR	CFI	IFI	RMSEA	PCLOSE
Model Criteria	χ^2/df <2	<0.1	>0.9	>0.9	<0.08	>0.05
Baseline model	1.923	.122	0.765	0.769	0.070	0.000
Achieved model	**1.733**	**.097**	**0.916**	**0.918**	**0.062**	**0.019**
Level of fit	Excellent fit	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

CMIN/DF = (CMIN=Chi Square or X_2 & DF=Degree of freedom); **RMR** = Root Mean Square Residual; **CFI** = Comparative Fit Index; **IFI** = Incremental Fit Index; **RMSEA** = Root Mean Square Error of Approximation and **PCLOSE** = P-Value of Close Fit.

Construct validity assessment

Since the model has an acceptable model fit, the constructs of the model need to be examined for reliability and validity. Table.4 presents a summary of the tests for the model's ten constructs. Firstly, all the constructs have an acceptable reliability value that is equal to or greater than 0.7. The values of the correlations between the constructs provide an indication of the discriminant validity, with all the correlations less than 0.63 between the independent constructs and less than 0.74 when both the independent and dependent constructs are included. In addition, all the factor loadings are high in general (ranging from 0.53 to 0.92) and significant at the p<0.01 level, suggesting convergent validity. The model meets the discriminant and convergent validities except for the system and software (SysSof) construct, which is not strong in the validity indicator (convergent validity), but has an acceptable discriminant validity. So, at this stage, Browne (2001) suggestion is followed, that use of CFA for exploratory purposes with pre-specified loadings be rejected and a sequence of modifications of the model is carried out in an attempt to improve the fit. Finally, when this is done, construct validity is established.

Table.4 Model Validity Measures

Construct	CR*	AVE**	MSV***	Practice	Service Provider	Leadership	Structure	Regulation	Networking	Management	Procedure	System and Software	e-Tendering Readiness
Practice	0.70	0.55	0.28	0.74									
Service Provider	0.78	0.55	0.54	0.39	0.74								
Leadership	0.78	0.55	0.37	0.22	0.52	0.74							
Structure	0.81	0.68	0.10	0.19	0.13	0.23	0.83						
Regulation	0.91	0.77	0.37	0.53	0.61	0.43	0.14	0.88					
Networking	0.77	0.53	0.40	0.25	0.60	0.61	0.32	0.40	0.73				
Management	0.85	0.66	0.25	0.23	0.38	0.50	0.20	0.21	0.37	0.81			
Procedure	0.83	0.71	0.40	0.31	0.38	0.30	0.15	0.49	0.63	0.23	0.84		
System and Software	0.70	0.44	0.18	0.34	0.41	0.24	0.22	0.23	0.32	0.23	0.09	0.66	
e-Tendering Readiness	0.84	0.64	0.54	0.34	0.74	0.40	0.30	0.47	0.51	0.31	0.27	0.43	0.80

*CR: Reliability **AVE: Convergent Validity (AVE > 0.5) ***MSV: Discriminant Validity (MSV < AVE , Square root of AVE greater than inter-construct correlations)

Variables (items) assessment

For assessment of the items, based on Kline (2016) advice, the model is potentially improved by removing the observed variables shown by the computed modification indices to have multicollinearity, as well as the items with low standardised regression weights, or which do not have significant path covariances with their factors (constructs). Accordingly, a number of items are removed in each round of assessing the model until all the conditions are met, so that finally, 27 out 55 items remain. Finally, these modifications appear to improve the model fit, developing the best-fit measurement model with the best GOF indices, as shown in Figure.3, Table.3 and Table.4.

Structural Model

Once the measurement model is validated, the structural model is conducted to examine the relationships between model constructs (Hooper et al. (2008). Structural model assessment includes examining the standardised path coefficients of the relationships in the model, and examining the model fit indices (Hair, 2010). Hair (2010) stresses that the focus in a SEM analysis is testing structural relationships by examining two issues: (1) overall and relative model fit as a measure of acceptance of the proposed model; and (2) structural parameter estimates, which are depicted with one-headed arrows on a path diagram. For this purpose, the standardised path coefficients are applied in the following section.

Path analysis

In this study, path analysis is used to test the research hypotheses by testing the models and relationships between the measured variables (Suhr, 2008). Path analysis uses the observed variables only and establishes a causal flow, in which both causal direct and indirect effects can be estimated (Kaplan, 2008). Therefore, the latent constructs with their observed items in the measurement model are imputed to become observed variables. The structural model is then specified with its path coefficients to test the research hypothesis.

Overall, the extended a priori e-TRM illustrated in Figure.2 specifies nine independent (exogenous) constructs, whereas e-Tendering readiness is identified as a dependent (endogenous) construct. Hair (2010) indicates that the structural model assessment procedure may include an examination of model fit indices and the standardised path coefficients in order to accept or reject the hypothesised relationships.

Testing the hypotheses

First, the research questions concern causation; therefore, the research is deductive, using a quantitative theoretical procedure. The following hypotheses are generated to answer the research questions using the structural model:

H01: *The* ***regulation*** *in the theme of Process significantly influences the organisation's level of readiness to implement e-Tendering.*

H02: *The* ***practice*** *in the theme of Process significantly influences the organisation's level of readiness to implement e-Tendering.*

H03: *The* ***procedures*** *in the theme of Process significantly influences the organisation's level of readiness to implement e-Tendering.*

H04: ***Leadership*** *in the theme of work environment significantly influences the organisation's level of readiness to implement e-Tendering.*

H05: *The* ***management*** *in the theme of work environment significantly influences the organisation's level of readiness to implement e-Tendering.*

H06: *In the theme of working environment, the* ***structure*** *construct has a significant influence on the organisation's level of readiness to implement e-Tendering.*

H07: *The level of an organisation's readiness to implement e-Tendering may be affected significantly by* ***systems and software*** *requirements.*

H08: *An organisation's level of readiness to implement e-Tendering may be significantly affected by the extent of* ***networking*** *within the organisation.*

H09: *A construction organisation's level of readiness to implement e-Tendering would likely be significantly affected by their* ***service providers****.*

For the hypothesised relationships to be supported, the standardised path coefficients need to be significant at the $p < .05$ level to be considered meaningful (Byrne, 2016). The results of the structural model assessment are presented in Table 5 and Figure.4. According to the results, two of the nine coefficients paths (Service Provider and Structure) are statistically significant and are considered meaningful (.692 and .156), although the model fit result is poor and therefore cannot be accepted. The structure model's initial result can be further enhanced, however, as detailed in the following section.

Table.5 Structure Model Initial Results: "initial model"

Path (Hypothesis)	Standardised Path Coefficients	Estimate	S.E.	C.R.	P	Hypotheses Testing Results
e-TR<-- Regulation (H01)	.002	.002	.051	.032	.974	Not supported
e-TR <-- Practice (H02)	.001	.001	.047	.023	.981	Not supported
e-TR <-- Procedure (H03)	-.112	-.088	.056	-1.572	.116	Not supported
e-TR <-- Leadership (H04)	-.116	-.134	.078	-1.716	.086	Not supported
e-TR <-- Management (H05)	-.013	-.009	.033	-.264	.792	Not supported
e-TR <-- Structure (H06)	**.199**	**.156**	**.034**	**4.541**	*****	**Supported**
e-TR <-- System and Software (H07)	.071	.097	.067	1.441	.150	Not supported
e-TR <-- Networking (H08)	.106	.090	.080	1.117	.264	Not supported
e-TR <-- Service Provider (H09)	**.794**	**.692**	**.064**	**10.863**	*****	**Supported**

*** Significant at the $p < .05$; R^2 (squared multiple correlations) for e-Tendering Readiness = 72.

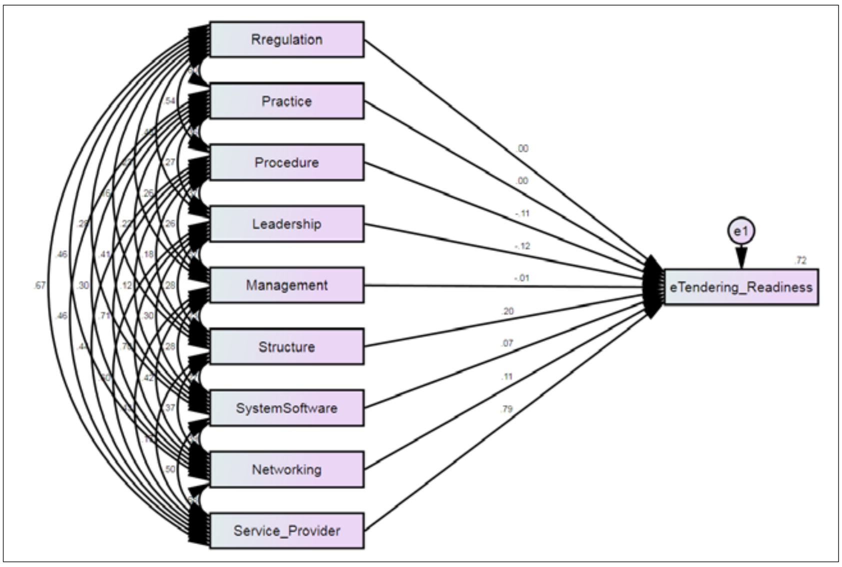

Figure.4 Initial structure model results

Model refinement

In this section, the model is refined to remove the negative weighted paths to ensure that its final form best explains the hypotheses. The model refinement procedure is followed by a hierarchical analysis, which Garson (2012) explains is a subset of an original structural model, with a particular link (path) added or removed. One of the paths between the nine independent (exogenous) constructs and dependent (endogenous) construct (e-Tendering) is removed each time until it fits and delivers acceptable results.

The results of the refinement of the final model are shown in Figure.5, Table.6 Table.7. The results of the standardised path coefficients in the final model show the improvement of the model fits and the number of the significant paths that are significant. According to the final model result, three coefficient paths (Service Provider, System and Software and Structure) are statistically significant compared to the initial model. The model fits are also improved to an acceptable range, as presented in Table.6. This is a strong justification to remove some coefficient paths between the exogenous constructs and the e-Tendering readiness construct.

Table.6 Models fit results and criteria suggested by Hair (2010)

	CMIN/DF	RMR	CFI	IFI	RMSEA	PCLOSE
Model Criteria	χ^2/df <2	<0.1	>0.9	>0.9	<0.08	>0.05
Baseline model	-	.000	1.000	1.000	0.359	0.000
Achieved model	1.197	.008	0.999	0.999	0.032	0.576
Level of fit	Excellent fit	Acceptable	Excellent fit	Excellent fit	Excellent fit	Excellent fit

*** Significant at the p < .05; R^2 (squared multiple correlations) for e-Tendering Readiness = 72.

Table.7 Structure Model final Results “final model”

Path (Hypothesis)	**Standardised Path Coefficients**	**Estimate**	**S.E.**	**C.R.**	**P**	**Hypotheses Testing Results**
e-TR <-- Structure (H06)	.187	.147	.032	4.600	***	Supported
e-TR <-- System and Software (H07)	.096	.130	.063	2.069	.039	Supported
e-TR <-- Service Provider (H09)	.733	.639	.039	16.235	***	Supported

*** Significant at the p < .05

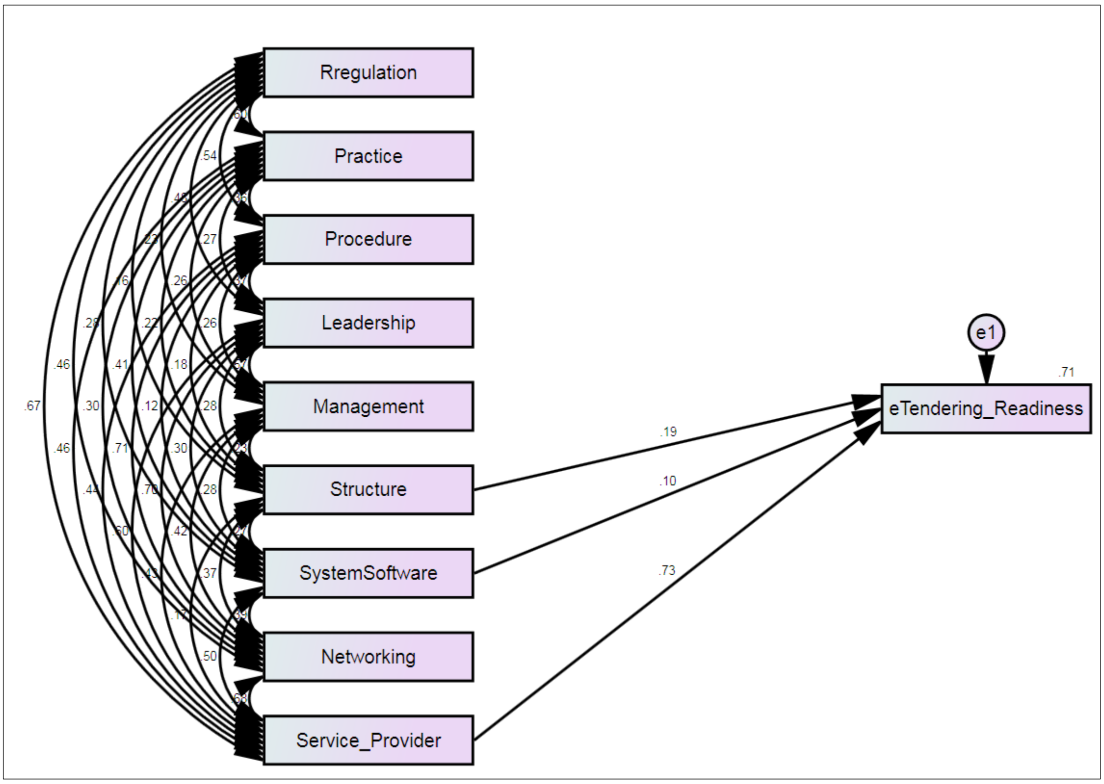

Figure.5 Final structure model results

The final model better explains the relationship between constructs and helps to confirm or reject the research hypotheses. Consequently, the final model, which we now call the “Posterior model”, is discussed in the following section.

7. DISCUSSION

Posterior model

The final model reveals that Structure, System and Software and Service Provider constructs influence the e-Tendering Readiness, as illustrated in Figure.6. It is clear that the Service Provider has the most influence in ensuring effective e-Tendering Readiness. Once the organisation Service Provider is prepared, the organisation is ready for e-Tendering practice. Structure, System and Software also have an influence on e-Tendering readiness; however, this appears to be not as strong as the Service

Provider effect. Furthermore, a strong correlation between the Service Provider and System and Software constructs is found at 0.5.

Posterior e-TRM vs a priori e-TRM

Importantly, the Posterior e-TRM differs from the extended a priori e-TRM in terms of construct numbers for two reasons. First, although the previous models (not items) are used to develop the e-TRM and become part of it, they have not been examined statistically. If these models are empirically tested, they may be found to yield similar results to the Posterior e-TRM's results.

Second, for the e-Tendering constructs and the items, ranking their importance is different from measuring the readiness. Moreover, when developing the a priori e-TRM, the items used are importance, CSFs, barriers or drivers, but not for measuring purposes. However, the a priori e-TRM uses the available items with their respective constructs, which influences the study's conceptual model. Third, the conceptual e-TRM is a worldwide perspective. Due to the nature of the available literature, it offers general resources and is not specific to the Saudi Arabian perspective. Thus any empirical experiment conducted for construction e-Tendering will use the same a priori e-TRM but will have a different Posterior e-TRM.

Lastly, the Posterior e-TRM is different in terms of constructs number only; however, it is has the stability constructs of consistency, item grouping and items reflecting the same construct. The PCA confirms 9 out of 11 (around 80%) of constructs, which indicates that the e-TRM is narrowed down to its effective constructs, as explained in Table.8.

Table.8 Constructs and items life cycle through this research

Construct		a priori e-TRM	Extended a priori e-TRM	Posterior e-TRM
Staff		√		
Skill		√		
Regulation			√	
Practice		√	√	
Procurers		√	√	
Leadership		√	√	
Management		√	√	
Cultural		√	√	
Structure		√	√	√
System and Software		√	√	√
Networking		√	√	
Communication	Service Providers	√	√	√
Market		√		

Technical		√		
e-Tendering Readiness		√	√	√

Attributable to Saudi Arabian conditions

The study suggests the Posterior e-TRM positively affects the Saudi Arabian context. This is clear from the analysis of the questionnaire survey, where the service provider has the lowest (average mean = 2.84) readiness ranking among the respondents organisations' for e-Tendering. Moreover, the SEM for the structure construct focuses solely on the hierarchical organisation's *complexity* and *support for IT implementation*. This helps Saudi organisations to concentrate their efforts when assessing their readiness in term of organisation structure. Another key area that needs attention is the organisations' systems. The SEM results for system and software constructs reveals that the current organisations' *ad hoc* system types, incompatible systems and system integration have an impact on e-Tendering readiness. Note that these systems are not e-Tendering systems but are organisational systems.

In conclusion, the Structure, System and Software and Service Provider constructs can be play a key role in successful e-Tendering implementation, as verified by the positive effect of e-Tendering readiness.

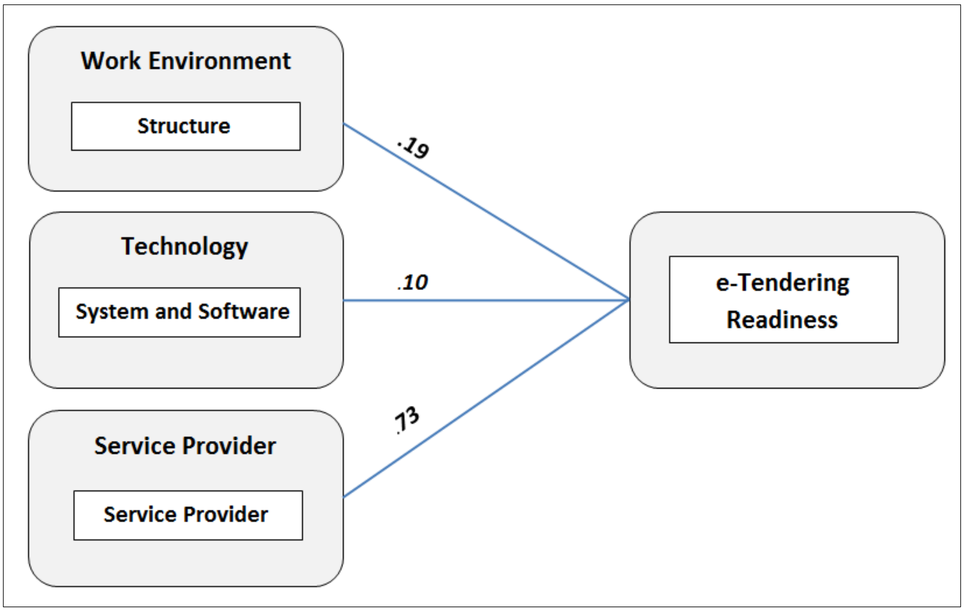

Figure.6 e-Tendering Readiness Posterior model

8. CONCLUSION

The paper highlights the importance of having pre-implementation e-Tendering assessment, or readiness assessment, for construction organisations. Frist of all, this paper is choosing Saudi Arabia to verified the model for some reasons: A) there are no enough literature review about e-Tendering in the Middle East. B) Saudi Arabia has become one of the most technologically active countries in the Middle East. Which is their IT ranking in e- Participation grew from 83 in 2005 to 39 in 2016 worldwide. C) last reason for choosing the Saudi Arabia is emerging form booming of construction in the area.

For that, this paper aims to verify the e-Tendering Readiness model for e-Tendering in construction. The first section analyses the FA through an assessment of internal consistency and item-total correlations. Then, the assessment of the scale’s reliability shows that the measurement scales, through confirmatory factor analysis, can be used to examine the model constructs for their reliability and validity. The results of the CFA are used in the model assessment, which is presented in the SEM and used to assess and improve the conceptual extended e-TRM. The assessment results indicate that the specified measurement model has acceptable levels of fit, convergent validity and discriminant validity. Then, the analysis proceeds to a specification and assessment of the structural model through SEM. The hypothetical relationships between the model constructs and e-Tendering readiness are assessed. Then, the hierarchical analysis is carried out to produce the final model. The results from the structural model assessment show that there is a positive relationship between three constructs (Structure, System and Software and Service Provider) and e-Tendering Readiness. Finally, the e-Tendering Posterior model is developed and verified for the Saudi Arabian context.

Practical implications

This paper is updating previous IT/IS models in construction for e-Tendering by adding the verified e-TRM the literature and the body of knowledge in the construction industry. The findings can be applied to the construction society in many ways. Firstly, to the body of the knowledge by having e-TRM itself and perceptions of service providers for first time. The e-TRM can be use with by different application to assess the organisation readiness. The assessors will understand how is the impact of each area of the model on the organisation e-Tendering readiness based on the e-TRM results. Secondly, develop e-Tendering Readiness Assessment Framework can help to make another e-Tendering readiness assessment in deferent country or context easily.

Lastly, the e-TRM has a practical contribution to the industry which makes a direct and significant contribution to the system providers. The system providers can focus on the area that has a positive impact on the e-Tendering readiness.

Research limitation and proposals for future research

The empirical test for the e-TRM is restricted to Saudi Arabia which, though not atypical of most countries' e-Tendering around the world, needs to be further tested in other areas for additional verification. So, similar studies may be conducted in various countries where best practice in e-Tendering is not observed, to strengthen e-Tendering knowledge. Moreover, since this paper focuses on assessing an organisation's readiness for e-Tendering, future research could focus on assessing an organisation's maturity in e-Tendering. Development of the e-TRM model follows the pattern of IT/IS model development. As explained by Eadie et al. (2012), the e-Readiness model is used for pre-adoption assessment (as in this research case), while the maturity model is used for post-adoption assessment. Tetlay and John (2009) define maturity assessment as an evaluation of "when [an organisation has] achieved a defined and implemented system". For this purpose, it will be very useful to develop a maturity model for e-Tendering.

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